

APPLICATION

FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, **Paul A. Knight**, a citizen of Canada, and **Carl Axel Ingemar Kabrell**, a citizen of Sweden, have invented a new and useful dry-wet thermal management system of which the following is a specification:

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2
3 **Dry-Wet Thermal Management System**
4
5

6 **CROSS REFERENCE TO RELATED APPLICATIONS**

7 Not applicable to this application.
8
9

10 **STATEMENT REGARDING FEDERALLY**
11 **SPONSORED RESEARCH OR DEVELOPMENT**

12 Not applicable to this application.
13
14

15 **BACKGROUND OF THE INVENTION**
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18

19 **Field of the Invention**
20

21 The present invention relates generally to spray cool thermal management
22 devices and more specifically it relates to a dry-wet thermal management system for
23 providing simultaneous spray cooling and dry cooling for a plurality of electronic
24 cards.
25
26

Description of the Related Art

The present invention relates to the thermal management of electronic components that are mounted upon electronic cards (a.k.a. expansion boards) or substrates. In a card level system, a plurality of cards are electrically connected within sockets upon a backplane (e.g. motherboard, etc.). Electronic cards are utilized in various applications such as personal computers, workstations, server computers, rack mounted services, network routers, network switches, telephone equipment (DWDMs, ADMs, TDMs, switches, repeaters and the like), and military applications (vehicle, aircraft, etc.). Examples of electronic cards include but are not limited to modems, video processors, network interfaces, processors, memory, hard drive controllers, hard drives, mouse controller, keyboard controller, global position systems, wireless cards, backplane controller cards and the like.

“Dry cooling” (i.e. air cooling) has been in usage for years for cooling electronic components. An example of a dry cooling system is a conventional desktop computer with a fan that passes air over the electronic components to cool the same. Dry cooling technology is acceptable for low powered electronic components.

Modern electronic devices have increased thermal management requirements. Conventional dry cooling technology simply is not capable of efficiently cooling modern high-end electronics. “Spray cooling” is being adopted today as the most efficient option for thermally managing electronic systems. United States Patent No. 5,220,804 entitled High Heat Flux Evaporative Spray Cooling to Tilton et al. describes the earlier versions of spray cooling technology. United States Patent No. 6,108,201 entitled Fluid Control Apparatus and Method for Spray Cooling to Tilton et al. also describes the usage of spray cooling technology to cool a printed circuit board. Spray cooling may be performed locally (i.e. where the chip is sprayed directly), globally (i.e. where the chip and

1 surrounding electronics/boards are also sprayed), a combination of locally and globally, or
2 in conjunction with air cooling or other cooling methods.

3
4 While there are many benefits in utilizing spray cooling technology, there are
5 some detriments. One of the detriments with spray cooling technology is the relatively
6 high cost of creating a spray cooling system capable of thermally managing all of the
7 electronic devices, electronic cards and the like for an electronic system. Another
8 problem with spray cooling technology is the increased weight of the thermal
9 management unit. A further problem with spray cooling technology is that not all
10 electronic devices are suitable for usage within a liquid coolant environment. Another
11 problem with spray cooling technology is that to replace, repair or test any electronic
12 device within a spray chassis the seal must be broken to the spray chassis thereby
13 leading to the loss of coolant.

14
15 While these devices may be suitable for the particular purpose to which they
16 address, they are not as suitable for providing simultaneous spray cooling and dry
17 cooling for a plurality of cards sharing a common backplane. Conventional thermal
18 management systems are suitable only for low or high heat flux applications with no
19 thermal management system serving the need for mixed heat flux applications where
20 some electronic devices may be cooled by dry cooling and other electronic devices
21 cooled by spray cooling.

22
23 In these respects, the dry-wet thermal management system according to the
24 present invention substantially departs from the conventional concepts and designs of
25 the prior art, and in so doing provides an apparatus primarily developed for the
26 purpose of providing simultaneous spray cooling and dry cooling for a plurality of
27 cards sharing a common backplane.

1

2 **BRIEF SUMMARY OF THE INVENTION**

3

4 In view of the foregoing disadvantages inherent in the known types of thermal
5 management devices now present in the prior art, the present invention provides a new
6 dry-wet thermal management system construction wherein the same can be utilized for
7 providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a
8 common backplane.

9

10 The general purpose of the present invention, which will be described
11 subsequently in greater detail, is to provide a new dry-wet thermal management system
12 that has many of the advantages of the thermal management devices mentioned
13 heretofore and many novel features that result in a new dry-wet thermal management
14 system which is not anticipated, rendered obvious, suggested, or even implied by any
15 of the prior art thermal management devices, either alone or in any combination
16 thereof.

17

18 To attain this, the present invention generally comprises a chassis having a dry
19 chamber and a spray chamber, a first opening within a rear portion of the chassis
20 extending into the spray chamber, a second opening within the rear portion of the
21 chassis extending into the dry chamber, and a main backplane secured and sealed to
22 the rear portion of the chassis. Electronic cards may be electrically coupled within
23 sockets of the main backplane within both the dry chamber and the spray chamber.
24 The cards within the spray chamber are typically high heat flux components with
25 increased cooling requirements and the cards within the dry chamber are typically low
26 heat flux components with reduced cooling requirements. In addition, cards within the
27 dry chamber are sometimes not compatible with the cooling fluid of the spray
28 chamber. A spray cool system is within the spray chamber and a dry cool system is
29 within the dry chamber.

1
2 There has thus been outlined, rather broadly, the more important features of the
3 invention in order that the detailed description thereof may be better understood, and
4 in order that the present contribution to the art may be better appreciated. There are
5 additional features of the invention that will be described hereinafter and that will form
6 the subject matter of the claims appended hereto.

7
8 In this respect, before explaining at least one embodiment of the invention in
9 detail, it is to be understood that the invention is not limited in its application to the
10 details of construction and to the arrangements of the components set forth in the
11 following description or illustrated in the drawings. The invention is capable of other
12 embodiments and of being practiced and carried out in various ways. Also, it is to be
13 understood that the phraseology and terminology employed herein are for the purpose
14 of the description and should not be regarded as limiting.

15
16 A primary object of the present invention is to provide a dry-wet thermal
17 management system that will overcome the shortcomings of the prior art devices.

18
19 A second object is to provide a dry-wet thermal management system for
20 providing simultaneous spray cooling and dry cooling for a plurality of cards sharing a
21 common backplane.

22
23 Another object is to provide a dry-wet thermal management system that is cost
24 effective and efficient.

25
26 An additional object is to provide a dry-wet thermal management system that
27 has a reduce weight and size.

1 A further object is to provide a dry-wet thermal management system that
2 reduces the cost of electronic devices utilized by reducing the need for coolant tolerant
3 specifications.

4
5 Another object is to provide a dry-wet thermal management system that reduces
6 coolant loss within a spray cooling system by reducing access to the spray chamber.

7
8 A further object is to provide a dry-wet thermal management system that
9 effectively cools low heat flux and high heat flux electronic components.

10
11 Another object is to provide a dry-wet thermal management system that utilizes
12 a common backplane for electronic cards positioned within a dry chamber and a spray
13 chamber.

14
15 An additional object is to provide a dry-wet thermal management system that
16 increases system reliability and access.

17
18 Other objects and advantages of the present invention will become obvious to the
19 reader and it is intended that these objects and advantages are within the scope of the
20 present invention.

21
22 To the accomplishment of the above and related objects, this invention may be
23 embodied in the form illustrated in the accompanying drawings, attention being called
24 to the fact, however, that the drawings are illustrative only, and that changes may be
25 made in the specific construction illustrated and described within the scope of the
26 appended claims.

1
2 **BRIEF DESCRIPTION OF THE DRAWINGS**
3

4 Various other objects, features and attendant advantages of the present
5 invention will become fully appreciated as the same becomes better understood when
6 considered in conjunction with the accompanying drawings, in which like reference
7 characters designate the same or similar parts throughout the several views, and
8 wherein:
9

10 FIG. 1 is an upper perspective view of a prior art dry cooling device.
11

12 FIG. 2 is a front view of the present invention illustrating the spray chamber
13 and the dry chamber.
14

15 FIG. 3 is a front perspective view of the present invention.
16

17 FIG. 4 is a rear perspective view of the present invention illustrating the
18 common backplane.
19

20 FIG. 5 is an exploded rear perspective view of the present invention illustrating
21 the seals
22

23 FIG. 6 is a rear perspective view of the present invention utilizing a secondary
24 backplane connected to the main backplane.
25

26 FIG. 7 is a front perspective view illustrating an alternative variation of the
27 spray chamber.
28

1 FIG. 8 is a front perspective view illustrating an alternative variation of the dry
2 chamber.

3

4 FIG. 9 is a rear perspective view of an alternative variation of the dry chamber.

5

6

DETAILED DESCRIPTION OF THE INVENTION

A. Overview

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. 2 through 9 illustrate a dry-wet thermal management system 10, which comprises a chassis 20 having a dry chamber 28 and a spray chamber 26, a first opening 22 within a rear portion 21 of the chassis 20 extending into the spray chamber 26, a second opening 24 within the rear portion 21 of the chassis 20 extending into the dry chamber 28, and a main backplane 40 secured and sealed to the rear portion 21 of the chassis 20. Electronic cards 12 may be electrically coupled within sockets 42 of the main backplane 40 within both the dry chamber 28 and the spray chamber 26. The cards 12 within the spray chamber 26 are typically high heat flux components with increased cooling requirements and the cards 12 within the dry chamber 28 are typically low heat flux components with reduced cooling requirements and/or are not compatible with the cooling fluid of spray chamber 26. A spray cool system is within the spray chamber 26 and a dry cool system is within the dry chamber 28.

B. Chassis (Dry Chamber and Wet Chamber)

As shown in Figures 2 through 9 of the drawings, the chassis 20 may have various shapes, structures and configurations. The chassis 20 illustrated in the drawings should not be interpreted to limit the scope of protection of the present invention. Chassis 20 may be freestanding or mounted into a rigid structure, such as but not limited to a network rack.

More particularly, the chassis 20 has at least one dry chamber 28 and at least one spray chamber 26. The dry chamber 28 and the spray chamber 26 may be

1 separated within the chassis **20** by a solid divider wall **30** as shown in Figures 2 and 3
2 of the drawings.

3
4 The dry chamber **28** and the spray chamber **26** also are preferably enclosed by
5 access doors/panels (not shown) as is well known in the art. The access door/panel
6 connected to the spray chamber **26** preferably is sealed to the spray chamber **26** to prevent
7 coolant loss. It can be appreciated that the access doors/panels for the spray chamber **26**
8 and the dry chamber **28** may be connected to one another or comprised of a single
9 structure.

10
11 The dry chamber **28** and the spray chamber **26** may be positioned within an
12 overall structure as separate compartments (see Figures 7 and 8) or attached to one
13 another (see Figure 9). Figure 7 illustrates the dry chamber **28** completely or partially
14 surrounding the spray chamber **26**. Figure 8 illustrates the spray chamber **26** completely or
15 partially surrounding the dry chamber **28**. Figure 9 illustrates a dry chamber **28** attached to
16 the spray chamber **26** utilizing conventional fasteners thereby allowing “swapping” of the
17 dry chamber **28** or the spray chamber **26** with a new chamber **26, 28**.

18
19 The dry chamber **28** is designed to allow for airflow to pass through and make
20 contact with the dry cards **12** within the dry chamber **28**. Various well-known dry
21 cooling technologies may be utilized to pass air through the dry chamber **28**. For
22 example, a fan **50** may be fluidly connected to the dry chamber **28** as shown in Figures
23 2 through 9 of the drawings.

24
25 In addition, the dry chamber **28** preferably includes a plurality of vents **29**
26 within the walls, floor and ceiling of the dry chamber **28** allowing for the free flow of
27 air thereby maintaining a desired temperature of the electronic cards **12** within the dry
28 chamber **28**.

1 The spray chamber 26 is designed to allow for liquid coolant to contact the
2 cards 12 thereby conducting the thermal energy generated by the wet cards 12.
3 Various well-known liquid coolant thermal management technologies may be utilized
4 within the spray chamber 26 for thermally managing the wet cards 12 within the spray
5 chamber 26. The cards 12 positioned within the spray chamber 26 must be capable of
6 being positioned within a dielectric coolant.

7
8 For example, a spray unit 60 is preferably positioned within the spray chamber
9 26 and fluidly connected to a pump unit 62. The pump unit 62 fluidly receives used
10 coolant from within the spray chamber 26 and preferably thermally conditions the
11 coolant through a heat exchanger prior to transmission to the spray unit 60. U.S.
12 Patent Nos. 5,220,804 and 6,108,201 illustrate spray cooling technology that may be
13 utilized within the present invention and are hereby incorporated by reference into this
14 application.

15
16 The spray chamber 26 is designed to receive at least one electronics card 12
17 capable of being spray cooled. The “wet cards” 12 are preferably high heat flux cards
18 12 that generate a significant amount of heat during operation thereof.

19
20 The dry chamber 28 is designed to receive at least one electronics card 12
21 capable of being dry/air cooled. The “dry cards” 12 are preferably low-medium heat
22 flux cards 12 that generate relatively lower amounts of heat during operation thereof
23 compared to the wet cards 12. Dry cards 12 are generally less expensive because they
24 do not require operation within a liquid coolant.

25
26 **C. Main Backplane**

27 As shown in Figures 2 and 5 of the drawings, a first opening 22 is positioned
28 within a rear portion 21 of the chassis 20 extending into the spray chamber 26. As

1 further shown in Figures 2 and 5 of the drawings, a second opening 24 is positioned
2 within the rear portion 21 of the chassis 20 extending into the dry chamber 28.

3
4 The first opening 22 and the second opening 24 may have various shapes, sizes
5 and locations within the chassis 20. However, the first opening 22 and the second
6 opening 24 are preferably sized sufficiently to accommodate the sockets 42 attached to
7 the main backplane 40 and/or the secondary backplane 44 as best illustrated in Figure
8 2 of the drawings.

9
10 The main backplane 40 is attached to the rear portion 21 of the chassis 20 by
11 various attachment means such as fasteners, adhesive, sealants, brackets, clamps and
12 the like. The main backplane 40 is preferably sealed about the first opening 22 and the
13 second opening 24 to prevent coolant from escaping from the spray chamber 26. It can
14 be appreciated that only the spray chamber 26 may be sealed by the main backplane 40
15 since airflow through the second opening 24 will not interfere with the thermal
16 management of the dry cards 12.

17
18 The main backplane 40 has at least one dry socket extending into the dry
19 chamber 28 and at least one wet socket extending into the spray chamber 26 as shown
20 in Figure 2 of the drawings. The sockets 42 may be comprised of any electronic
21 receptacle capable of electrically receiving a card 12.

22 23 *E. Seal*

24 As shown in Figure 5 of the drawings, at least one seal is positioned between
25 the rear portion 21 of the chassis 20 and the main backplane 40 for sealing about the
26 first opening 22 and the second opening 24. The seal may be comprised of a single
27 structure or a plurality of seal structures.

1 Figure 5 illustrates a first seal **70** surrounding the first opening **22** and a second
2 seal **72** surrounding the second opening **24**. The first seal **70** and the second seal **72**
3 may be comprised of various structures and materials commonly utilized to construct
4 seals. It can be appreciated that only the first seal **70** is required to operate the present
5 invention by sealing the spray chamber **26**. The seal **70, 72** may also be formed
6 utilizing various other materials/structures such as but not limited to sealants, resins,
7 adhesives, gaskets, O-rings and the like.

8 9 ***F. Secondary Backplane***

10 In addition to a main backplane **40**, a secondary backplane **44** may be attached
11 and electrically connected to the main backplane **40** as shown in Figures 6 and 9 of the
12 drawings. The main backplane **40** has at least one dry socket extending into the dry
13 chamber **28** and the secondary backplane **44** has at least one wet socket extending into
14 the spray chamber **26**.

15
16 A connector member **46** is electrically positioned between the main backplane
17 **40** and the secondary backplane **44** as further shown in Figures 6 and 9 of the
18 drawings. The secondary backplane **44** and the main backplane **40** are preferably
19 sealed to the rear portion **21** of the chassis **20** about the first opening **22** and the second
20 opening **24** respectively.

21 22 ***G. Operation***

23 In operation of the present invention, at least one high heat flux card **12** is
24 positioned within the wet chamber and electrically connected within one of the sockets
25 **42** attached to the main backplane **40** as shown in Figure 1 of the drawings. The spray
26 chamber **26** is then sealed. In addition, at least one low heat flux card **12** is positioned
27 within the dry chamber **28** and electrically connected within one of the sockets **42**
28 attached to the main backplane **40** as shown in Figure 1 of the drawings. An access
29 door/panel may then be closed upon the dry chamber **28**.

1
2 The electronic cards **12** may then be electrically operated as desired to perform
3 a desired task. Before, during and/or after operation of the electronic cards **12**, a liquid
4 coolant is applied to the wet cards **12** within the spray chamber **26** for thermally
5 managing the wet cards **12**. Various sensors within the spray chamber **26** determine
6 the coolant flow rate and coolant temperature applied to the wet cards **12** depending
7 upon the heat flux of the wet cards **12** and the desired temperature of the wet cards **12**.

8
9 In addition to operation of the spray cooling system within the spray chamber
10 **26**, airflow is applied within the dry chamber **28** for thermally managing the dry cards
11 **12** within thereof. A fan **50** or similar air movement device may be utilized to cause
12 air to flow through the dry chamber **28** thereby thermally managing the electronic
13 cards **12**. Various sensors within the dry chamber **28** determine the amount of airflow
14 required to maintain a desired temperature within the dry cards **12**.

15
16 If the user requires access to the cards **12** within the dry chamber **28**, the access
17 door/panel is simply removed without having to disturb the spray chamber **26**. The
18 user is then able to make the required additions/repairs within the dry chamber **28** and
19 close the same in an efficient manner without losing any coolant. If the user requires
20 access to the cards **12** within the spray chamber **26**, the access door/panel is removed.
21 A small volume of liquid coolant may be lost in opening the spray chamber **26**, but the
22 amount of coolant loss is less than if a larger spray chamber **26** were opened. The user
23 is then able to make the required additions/repairs within the spray chamber **26** and
24 close the same in an efficient manner without losing significant amounts of coolant.

25
26 As to a further discussion of the manner of usage and operation of the present
27 invention, the same should be apparent from the above description. Accordingly, no
28 further discussion relating to the manner of usage and operation will be provided.

1 With respect to the above description then, it is to be realized that the optimum
2 dimensional relationships for the parts of the invention, to include variations in size,
3 materials, shape, form, function and manner of operation, assembly and use, are
4 deemed to be within the expertise of those skilled in the art, and all equivalent
5 structural variations and relationships to those illustrated in the drawings and
6 described in the specification are intended to be encompassed by the present invention.

7
8 Therefore, the foregoing is considered as illustrative only of the principles of
9 the invention. Further, since numerous modifications and changes will readily occur to
10 those skilled in the art, it is not desired to limit the invention to the exact construction
11 and operation shown and described, and accordingly, all suitable modifications and
12 equivalents may be resorted to, falling within the scope of the invention.